

The Impact of Land Surface Inhomogeneity on Shallow Clouds over SGP

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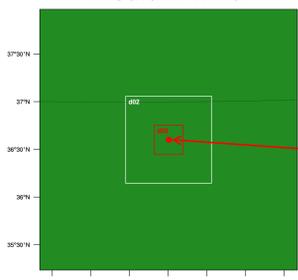
Motivation

What is the potential impact of subgrid-scale land surface heterogeneity on grid-scale atmospheric boundary layer and shallow cloud development in climate models?

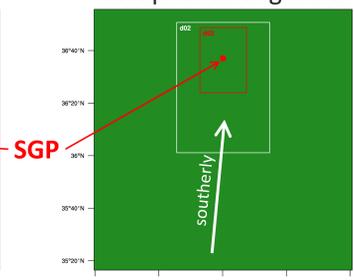
Approach

- **Nested WRF-LES using realistic lateral boundary conditions from regional analysis**
 - Domain 3: $dx=100$ m, $\sim 30 \times 30$ km²
 - Domain 2: $dx=300$ m, $\sim 100 \times 100$ km²
 - Domain 1: $dx=900$ m, $\sim 300 \times 300$ km²
 - NAM 3-hourly analysis/forecast ($dx=12$ km)
 - 304 vertical levels ($dz \approx 20$ m below 5 km)
 - Deardorff TKE SGS in d02, d03, YSU PBL in d01

Setup for weak to medium wind



Setup for strong wind

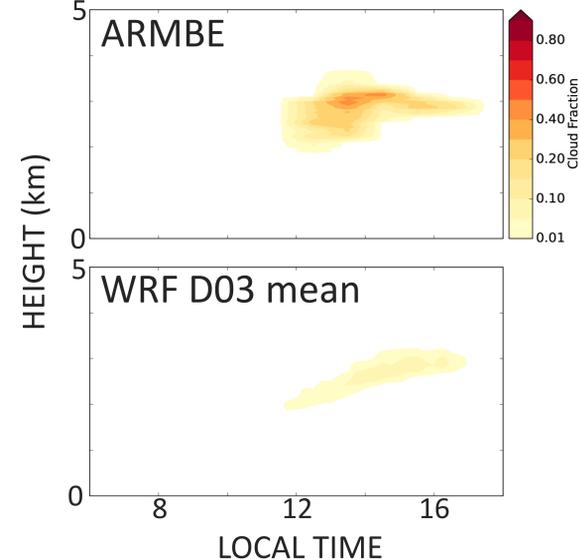


- **Interactive land surface model – NOAH LSM**
- **Multiple summertime shallow cloud cases over SGP** – different wind conditions, cloud amount and structures
- **NO_HETEROGENEITY experiment**
 - the values of surface sensible and latent heat fluxes calculated by LSM at each grid point are replaced by their domain averages before being passed on to the atmosphere model.
 - Mimics what happens in a climate model grid box, i.e., no subgrid-scale land surface heterogeneity and no subgrid-scale land-atmosphere interaction

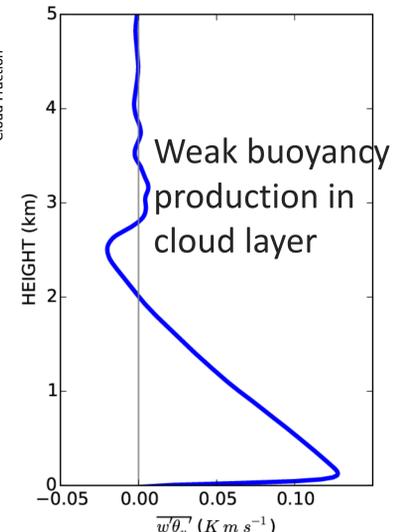
Results: 2008-05-16 Case

- Control simulation

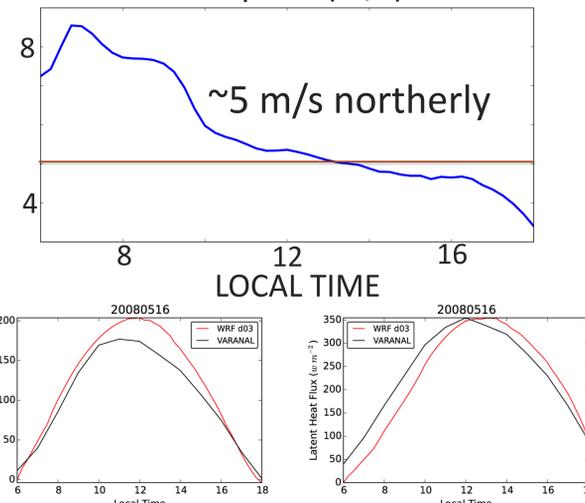
Cloud Fraction



Resolved buoyancy flux
D03 1500LST



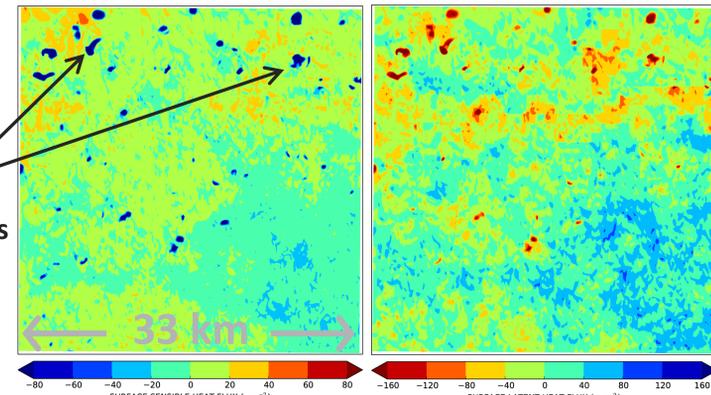
D03 mean low level (0-200 m)
wind speed (m/s)



Mean surface flux diurnal cycle is captured with a warm/dry bias.

- Simulated surface heterogeneity

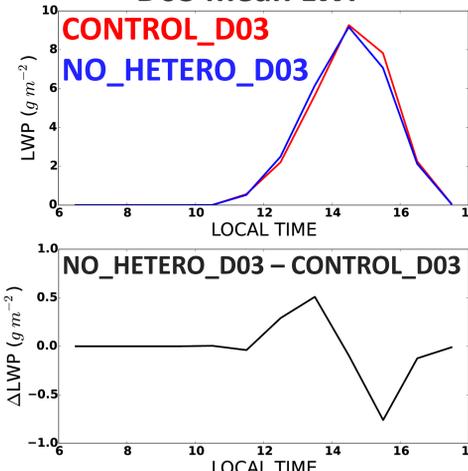
D03 Surface heat flux anomalies at 1200LST



Except for cloud shadows, surface sensible heat flux anomalies < 40 w/m², surface latent heat flux < 80 w/m².

- NO_HETEROGENEITY experiment

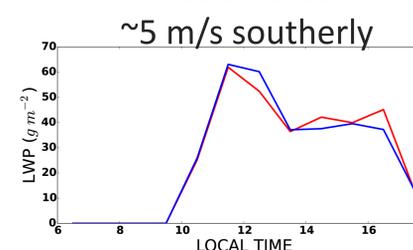
D03 mean LWP



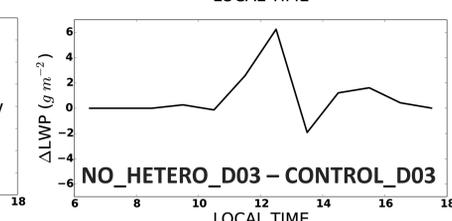
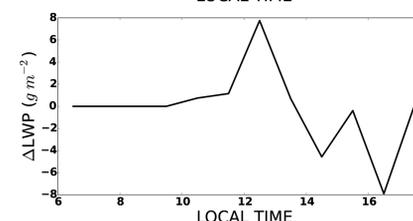
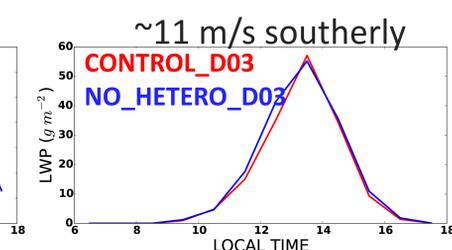
- no significant impact on cloud diurnal cycle
- $\sim 10\%$ change in D03 mean LWP

Results from other cases

2006-08-08



2007-05-14



Two other summer cases with larger LWP and different low level winds show similar responses.

Summary and Future Work

- Removing land surface heterogeneity in a $\sim 30 \times 30$ km² nested LES domain leads to $\sim 10\%$ change in mean cloud LWP but does not significantly impact the cloud diurnal cycle in three different shallow cloud cases over SGP.
- How important is the nonlocal (next grid box downwind) vs local impact?
- We will also examine the impact of surface heterogeneity on larger scales (e.g., 100 km), in other geographical locations, and on the initiation of precipitation.